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Hynobius tenuis (Caudata, Hynobiidae), a New Species of Salamander from Centeral Japan

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ABSTRACT—A new species of the salamander, *Hynobius tenuis*, is described from the mountainous areas of the southern part of Toyama Prefecture and the northern part of Gifu Prefecture. It differs from the previously known species of *Hynobius* in several diagnostic characters, mainly in the skull. It is most closely related to *H. hidamontanus* M. Matsui.

INTRODUCTION

In 1983, Nambu reported the occurrence of hynobiid salamanders which form transparent and ribbon-shaped egg sacs and cannot be attributed to any known species of *Hynobius* from the mountainous areas in the southern part of Toyama Prefecture [1]. After careful examination of many specimens and comparison with other species of *Hynobius*, it is concluded that this species is new to science. In the present paper, this hynobiid is described as a new species, *Hynobius tenuis*.

MATERIALS AND METHODS

Methods for morphological comparison and terms used mostly accord with Nambu [2]. Abbreviated terms used. Body: TOTL, total length; SVL, snout vent length, from snout to anterior angle of vent; TRL, trunk length; HL, head length; TAL, tail length; MTAH, maximum tail height; CTW, central tail width; HW, head width; FLL, fore limb length; HLL, hind limb length; MNCH, magnitude of number of costal folds when appressed limbs in life (+, overlapped; −, separated, ±0, just met). Development of the 5th toe: 3+, well developed; 2+, developed; 1+, rudimentary; −, lacking. Vomerine teeth series: IP, inner part (IPB in Nambu [2]); OP, outer part (OB [2]); DV (X [2]), distance between right and left vomers of inner nostrils; TIP (a1 [2]), distance between right and left tops of IP; MIP (a2 [2]), width of the middle of IP; LIP (b [2]), length of IP; LLOP, length of left OP; LROP, length of right OP. Tooth: VT, vomerine tooth; UJT, upper jaw tooth; MT, mandibular tooth. Skull, by soft-X ray picture: SL, skull length; PSL, posterior skull length; PSW, posterior skull width; POW, posterior orbital width; AOW, anterior orbital width; DM, distance between left and right maxillae; DPMM, horizontal distance between frontal tip of premaxilla and tip of maxilla.

Methods for making transparent and stained skull. 1) Skin and muscles are roughly stripped, 2) bathed in an aqueous solution of KOH(4%) and removing the muscles, 3) bathed in staining dye (alizarin) in 2% KOH, 4) bathed in 2% KOH until the cranium becomes transparent.

When not specially mentioned, variation in values of measurements is expressed by mean ± SE and ranges in mm and those of ratios are expressed by median and ranges in %.

All the specimens were fixed in 10% formalin and later deposited in 70% ethanol; all deposited at Toyama Science Museum (TOYA), Toyama, Japan.

Hynobius tenuis n. sp.
(Figs. 1, 2A-B, 3, 5A, 6A and 7A)

Hynobius sp.: Nambu, 1983 [1]: 78–81; figs. 1A, B, C; pl. IF.

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Fig. 1. Dorsal view of the holotype of *Hynobius tenuis*. Total length=99.0 mm.

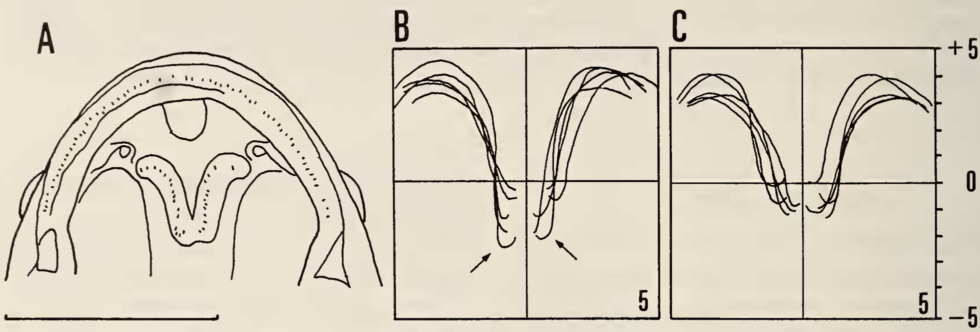

Fig. 2. Schematic drawing of vomerine teeth series. Methods of representation was described by Nambu [2]. A, *H. tenuis*, holotype; B, *H. tenuis*, holotype and 4 paratypes (TOYA-Am-384, 387, 390, 392); C, *H. hidamontanus* (TOYA-Am-411~414, 423). Bar=5 mm. Arrows show the holotype. Figure in a square shows the number of specimens.

Holotype. TOYA-Am-385; an adult male from a small stream, Arimine, Ooyama-machi, Toyama Prefecture; May 18, 1982; coll. Hisao Nambu.

Paratypes. A total of 14 males from the same locality as for the holotype: TOYA-Am-382~384 and 386~388, May 18, 1982; TOYA-Am-389~393, June 3, 1983; TOYA-Am-394~396, June 21, 1984. TOYA-Am-397~400, 3 males and 1 female from Mt. Ootsuji, Tateyama-machi, Toyama Prefecture; May 1, 1989: TOYA-Am-401~403, 3 males from Mizunashi, Toga-mura, Toyama Prefecture; June 15, 1988: TOYA-Am-404~407, 3 males and 1 female from Mt. Sore, Shirakawa-mura, Gifu Prefecture; May 20, 1983. Coll. Hisao Nambu.

Description

Holotype

Head flat and oval, with prominent eyes and blunt snout; lateral part somewhat swollen; an impressed line from the posterior angle of eye to the side of gular fold, a short vertical groove behind the angle of the mouth. Tongue oval. Trunk round dorsally and flattened ventrally, with a median line on both dorsum and venter. Costal grooves 12; costal folds 11; grooves on the ventral surface 9. Limbs moderately stout; MNCH, ±0. Fingers 4, 2-3-1-4 in order of length from the longest; toes 4, 3-2-4-1. Tail gradually flattened, not keeled, with blunt tip; basal and central sections rectangular and lanceolate-oblong, respectively.

Body measurements (mm): TOTL, 99.0; SVL, 53.2; TRL, 39.8; HL, 13.4; HW, 10.0; head depth at posterior angle of jaw, 6.2; eyelid length, 3.0; anterior rim of orbit to snout, 3.2; interobital distance, 3.4; snout to insertion of forelimb, 17.9; distance between external nares, 3.1; axilla to groin in left, 28.2; TAL, 45.8; tail width at base (posterior tip of cloaca), 4.1; tail height at base, 4.5; tail height at middle, 5.3; MTAH, 5.3; CTW, 3.0; FLL, 14.1; HLL, 16.6. Body weight in life

3.82 g.

Vomerine teeth series with narrowly V-shaped inner principal parts and short arcuate outer parts (Fig. 2A); anterior tips of IPs located between +3 and +4 and posterior tips between −2 and −3 (Fig. 2B). Measurement (mm): DV, 2.7; TIP, 1.6; MIP, 0.6; LIP, 1.6; LLOP, 0.4; LROP, 0.3.

Teeth small, with the bicuspid and reddish tips; in a single file; preparatory small teeth in the inner portion of a file of the upper jaw and mandibular teeth and in the outer of vomerine teeth hardly seen. Number of teeth: VT, 29; UJT, 60; MT, 61.

Skull (mm): SL, 10.0; PSL, 3.7; PSW, 5.8; POW, 2.9; AOW, 2.4; DM, 7.7; DPMM, 4.2. Trunk vertebrae 17, caudal vertebrae 26.

Color in life: Dorsum light brown with scatterd dark spots, which are often united with one another along costal grooves and at the upper portion of tail; venter dark gray; tail pale at the basal part. Small bluish white spots densely present on the lateral and ventral sides of trunk, the lower part of tail and upper surfaces of limbs.

Color in preservative: Dorsum light brown with dark spots as in life; venter gray to yellowish gray. White spots in life becoming paler.

Skull (Fig. 3)

Specimens examined: 5 male paratypes (TOYA-Am-386, 390, 393, 395, 406).

Skull well ossified, flat and moderately convex at the center of parietals; in the middle portion, narrower anteriorly than posteriorly; upper jaw bones consisting of maxilla and premaxilla strongly arcuate in outline. Maxilla slender with long and acuminate tip. Maxillary and premaxillary teeth vertically growing from the rim. Well-developed dorsal process of premaxilla. Nasal separated medially, truncate laterally and posteriorly; lateral margin not touching the dorsal process of maxilla, hence the lacrimal is visible in dorsal view. Prefrontal small and round posteriorly. Frontal truncate posteriorly, reaching the middle of skull. Parietal gradually dilated posteriorly and extending laterally. Vomers narrowly fan-shaped, gradually tapered to a point and connected with the protuberance of vomerine teeth posterolaterally, with round process laterally and V-shaped teeth series; lateral margin of dorsal bone visible in ventral view beyond the lateral margin of vomer. Parasphenoid gradually narrowed anteriorly. Prootics and exoccipitals separated.

Variation

Specimens examined: holotype (TOYA-Am-385), 16 male paratypes (TOYA-Am-382~384, 386~392, 394~396, 404~406), and 2 female para-

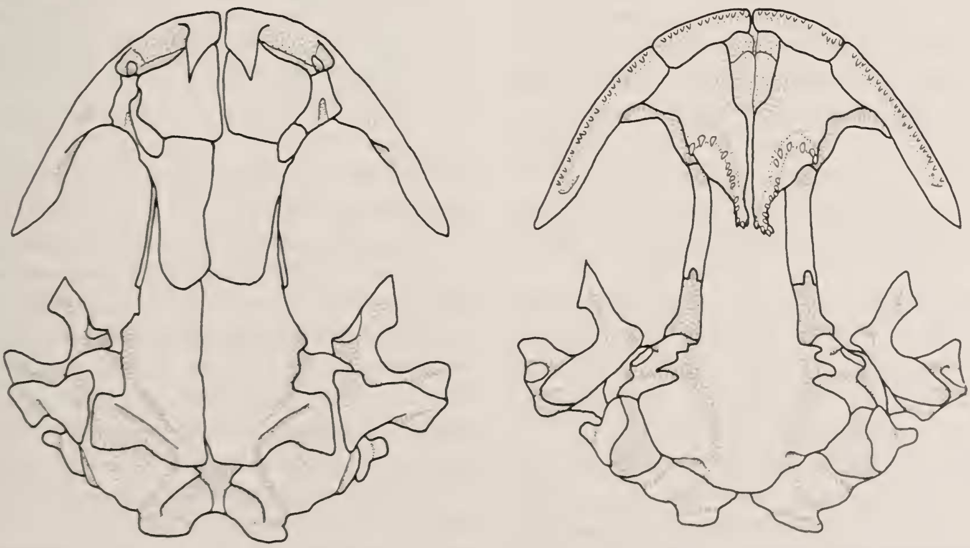

FIG. 3. Skull of *H. tenuis* (Paratype: TOYA-Am-393). Left, dorsal view; right, ventral view. Skull length = 10.1 mm.

types (TOYA-Am-407, 400).

Measurement of body (mm), ratios of each portion to SVL(%) and both ratios of TRL to HL and TAL to TRL: in 17 males, TOTA=92.1±1.15 (83.3–99.0), SVL=51.1±0.59 (46.9–54.4), HL=12.1±0.19 (10.5–13.4), TRL=38.8±0.48 (35.8–42.0), TAL=41.3±0.74 (36.2–45.8), HW=9.9±0.21 (8.9–12.2), FLL=13.8±0.16 (12.7–14.9), HLL=15.7±0.19 (14.2–16.8), CTW=3.6±0.10 (2.9–4.4), MTAH=5.7±0.15 (4.5–6.7), HL/SVL=23.8 (22.4–25.2), TRL/SVL=76.2 (71.7–77.6), TAL/SVL=80.5 (74.3–92.9), HW/SVL=19.0 (17.8–22.4), FLL/SVL=27.2 (24.4–30.3), HLL/SVL=31.1 (27.9–35.8), MTAH/SVL=11.2 (9.6–12.3). TRL/HL=3.20 (2.97–3.47), TAL/TRL=1.06 (0.98–1.20); in two females, TOTL=96.8 and 89.6, SVL=54.6 and 52.5, HL=12.4 and 12.7, TRL=42.2 and 39.8, TAL=41.6 and 37.1, HW=9.2 and 10.5, FLL=12.5 and 13.9, HLL=15.5 and 15.0, CTW=3.4 and 3.2, MTAH=5.2 and 5.4. Body weight (g): in 14 males, 3.6±0.19 (2.7–4.8); two females with eggs, 5.1 and 4.6.

In males, TAL longer than TRL and shorter than SVL; in females, TAL shorter than TRL; in both sexes, tail not keeled. MNCH: in 14 males, ±0=7 specimens, −1/2=1, −1=4, +1/2=2; in 2 females, −2=1 and −1=1. Modal number of costal grooves and costal folds 12 and 11, respectively: in 19 specimens of both sexes; 12 costal grooves, 14 specimens; 13, 5; 11 costal folds, 14; 12, 5. Fingers 4, toes 4. Fifth toe usually locking (−), sometimes rudimentary (+): in 19; 16 specimens, lacking on both hind libms; 2, rudimentary on both; 1, rudimentary on the left and lacking on the right. In 19 on left limbs: fingers 2-3-1-4 in 19; toes 3-2-4-1 in 15 with 4 toes, the second toe longer than the fourth toe in 18 and equal to the latter in 1.

Measurements of DV (mm) and ratios of each portion to DV (%): 11(1) or 12 males: DV=2.73±0.05 (2.5–3.0)(1), TIP/DV=62.6 (56.9–70.0), MIP/DV=26.5 (20.0–39.0), LIP/DV=51.3 (41.3–63.0), LLOP/DV=15.0 (11.3–23.0)(1). In 12 males, TIP longer than LIP in 10, equal to the latter in 1 and shorter than the latter in 1; the anterior tips of IPs located between +3 and 4.5 in 12 and the posterior tips between 0 and −2 in 11 (Fig. 2B). Number of teeth: 11(1) or 12 males; VT

Fig. 4. Geographical map of the area facing the Japan Sea side of Chubu District, Central Japan, showing localities of 4 species of the genus *Hynobius*. *H. tenuis,* closed circle; *H. hidamontanus,* closed rhomboid, quoted from Matsui [4]; *Hynobius* sp., closed rhomboid with question mark [1, 4]; *H. takedai,* closed square [2, 5], closed triangle, westernmost record of *H. lichenatus* [6]. Contours show an altitude of 1,000 m. An arrow shows the type locality of *H. tenuis,* Arimine, Ooyama-machi, Toyama Prefecture.

=26±1.02 (21–33), UJT=60.6±1.45 (55–74)(1), MT=63.3±1.53 (54–75).

Color: Dorsum light brown in life in most specimens, but dark brown in some specimens; white spots of trunk and tail vary from dense to sparse.

Skull: Measurement (mm) and ratios of each portion to skull length (%): 16(1) or 17 males, SL=9.6±0.13 (8.5–10.3), PSL=3.5±0.05 (3.0–3.7), PSW=5.6±0.06 (5.0–6.0), POW=2.8±0.05 (2.5–3.2), AOW=2.4±0.05 (2.1–2.7), DM=7.5±0.11 (6.7–8.2), DPMM=4.0±0.05 (3.6–4.2)(1); PSL/SL=36.4 (33.7–40.7), PSW/SL=58.3 (54.9–65.9), POW/SL=29.4 (25.0–37.6), AOW/SL=25.0 (22.0–29.4), SW/SL=78.7 (69.8–89.4), DM/

SL=41.3 (40.0–44.7)[1]; two females (TOYA-Am-407, 400), SL=9.5 and 9.5, PSL=3.4 and 3.4, PSW=6.1 and 5.6, POW=3.1 and 2.7, AOW=2.6 and 2.3, DM=8.1 and 7.8, DPMM=4.1 and 4.1.

Modal number of trunk vertebrae 17: in 18; 17 vertebrae, 14 specimens; 18, 4. Number of vertebrae (17 or 18) corresponds to that of costal grooves (12 or 13): in 18; 17 trunk vertebrae to 12 costal grooves, 13 specimens; 17 to 13, 1; 18 to 13, 4. Number of caudal vertebrae with unharmed tail and total vertebrae (mean±SD, ranges) in 17 males: caudal vertebrae, 22.7±3.5 (16–28); total vertebrae, 39.9±3.6 (33–45).

Egg sacks and eggs

Egg sacs transparent, ribbon-shaped and spiral ([1]: pl. I D); envelop weak; surfaces with many cross folds in egg sacks from all localities, though lacking the longitudinal stria. In 8 pairs of egg sacs with the post tail-bud embryonic stage (St. 31–35 by Sawano [3]) and complete water absorption after spawning from Arimine, Ooyama-machi, Toyama Prefecture, in June 1984: the length and width (in cm, mean±SD, ranges), 11.2±1.24 (9.0–12.5) and 1.3±0.04 (1.2–1.4); coiled number, 1.5 times in 12 egg sacs, 2.0 in 2, and 1.0 in 2.

Egg number (locality, number of pairs of egg sacs observed, mean±SE and ranges): Arimine, 8, 26.1±1.75 (18–35); Arimine, 14, 26.4±1.78 (20–33); Mt. Ootsuji, Ooyama-machi, Toyama Prefecture, 8, 35±3.18 (20–41), Shirakimine, Yatsuo-machi, Toyama Prefecture, 4, 25.8±1.38 (24–29); Mizunashi, Toga-mura, Toyama Prefecture, 12, 33.8±1.51 (29–44), Mt. Soure, Shirakawa-mura, Gifu Prefecture, 5, 32±1.92 (28–35). Egg diameter: Arimine, mean of 10 eggs in 5 pairs of egg sacs (mm), 2.56 (St. 1), 2.82 (St. 3), 2.60 (St. 7), 2.73 (St. 10), 2.96 (St. 12). Color of eggs from Arimine in preservative: dark brown on the animal hemisphere and pale brown on the vegetative side at St. 2 or yellowish brown at St. 10.

Egg sacs are deposited on the surfaces of fallen trees or on the roots of water plants in the swamp from Arimine, Ooyama-machi ([1]; pl. IA).

Distribution

The present species, *H. tenuis* n. sp., is known from the mountainous areas at the western side of the Hida Mountains in Central Japan, from 900 to 1,530m in altitude (Fig. 4). Toyama Prefecture: Arimine, Ooyama-machi (1,200 and 1,390 m); Mt. Ootsuji, Ooyama-machi (900 m); Mt. Shirakimine, Yatsuo-machi (1,530 m; only eggs); Mizunashi, Toga-mura (980 m and 1,390 m). Gifu Prefecture: Mt. Soure, Shirakawa-mura (1,230 m).

Etymology

The specific name "*tenuis*" is derived from the slender form of the body.

Japanese name, Yama-sanshô-uo.

REMARKS

The lack of the 5th toe, the small number of vomerine teeth, and the body proportion of the present species suggest that it is closely related to *H. hidamontanus* M. Matsui described from Hakuba-mura, Nagano Prefecture [4]. However, according to observation of 5 male skulls of *H. hidamontanus* (TOYA-Am-414∼417, 423), it is distinguishable from *H. hidamontanus* by the following features. 1) Upper jaw bone (Fig. 5): smoothly arcuate in the present species, angular at joint portion of maxilla and premaxilla in *H. hidamontanus*. Similarly, the former note is applicalbe to the present species and the latter to *H. hidamontanus* in the following notes. 2) Maxilla (Fig. 6): long with sharp toothless portion; short with small toothless portion. 3) Premaxilla (Figs. 6, 7): upper process is appreciably slanting posteriorly in lateral view and lower portion is vertical

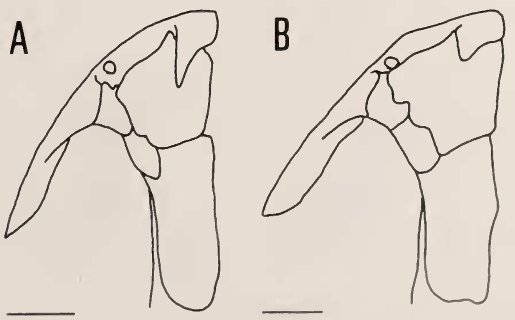

Fig. 5. Left frontal portion of skull, dorsal view. A, *H. tenuis* (TOYA-Am-386); B, *H. hidamontanus* (TOYA-Am-417). Bar=1 mm.

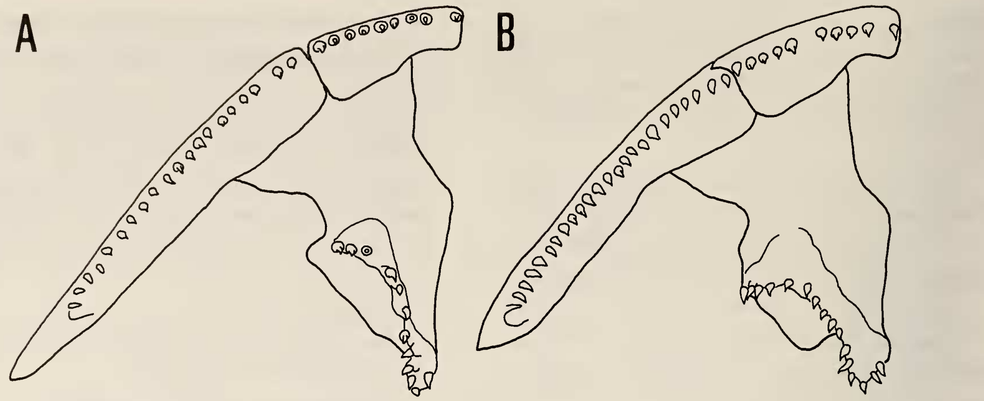

Fig. 6. Right frontal portion of skull, ventral view. A, *H. tenuis* (TOYA-Am-395); B, *H. hidamontanus* (TOYA-Am-417). Bar=2 mm.

(Fig. 7A), so that the front margin at the basal portion of teeth is not visible from the ventral side (Fig. 6A); upper process gently slanting posteriorly and lower portion curved insides (Fig. 7B), so that the front margin is visible (Fig. 6B). 4) Vomer (Fig. 6): narrow and gradually tapered to a point; wide and lacking in posterolateral portion. 5) Vomerine teeth series (Fig. 2): LIP is significantly larger (Mann-Whitney U-test, $P<0.01$); (12 males) LIP/DV=51.3 (41.3–63.0), (11 males) LIPP/DV=42.0 (33.8–47.8).

An unidentified *Hynobius* species from Oumi-machi, Niigata Prefecture, reported by Nambu [1] seems conspecific with the one reported by Higuma [7] as *Hynobius lichenatus* and by Matsui [4] as *H. hidamontanus*. It seems closely related to the present species; detailed discussion on the relationship between them will be made in a separate paper.

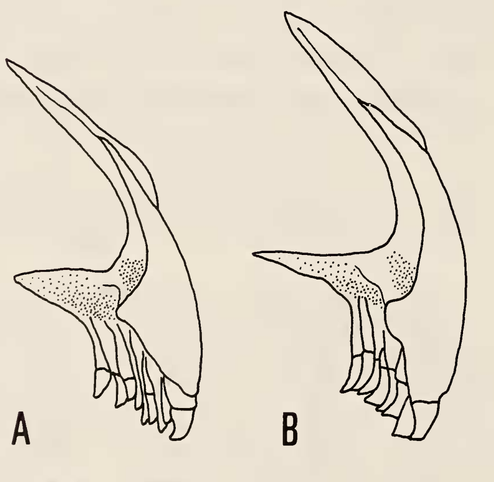

Fig. 7. Left premaxilla, right lateral view. A, *H. tenuis* (TOYA-Am-395); B, *H. hidamontanus* (TOYA-Am-414). Bar=1 mm.

The present species is different from *H. takedai* (Nambu [2]; Matsui *et al.* [5]) in the following points. 1) Number of vomerine teeth is smaller in the present species than in *H. takedai*: the present species (12 males) 26 ± 1.02 (21–33); (22 males) 38.3 ± 1.25 (31–55) [2], (23 males) 37.1 ± 1.4 (28–54) [5]. 2) Vomerine teeth series: V-shaped with short outer part; U-shaped with long outer part [2]. 3) Fifth toe: lacking (−); developed (2+) or well developed (3+) [2]. 4) Tail of the male: not keeled; keeled [2, 5]. Furthermore, an observation of 2 male skulls of *H. takedai* (TOYA-Am-266, 426) has revealed definite differences between the two in the skull features as follows: 1) Nasal: small with truncate margin laterally in the present species; large with developed process laterally in *H. takedai*. 2) Prefrontal: small with round tip; large with acute tip. 3) Frontal: short with truncate tip; long with acute tip. 4) Vomer: shallow; wide.

According to the features of the skull reported by Sato [8], one Korean, two Taiwanese and 13 Japanese *Hynobius* species can be easily distinguished from the present species by the following characteristics: 1) Lateral process of nasals in these species are developed. All the followings are the results by comparison with the present species. 2) Frontals of these species are longer with acute tip. 3) Prefrontals of *H. tsuensis, H. nigrescens, H. okiensis, H. kimurae* are longer. 4) Vomers of *H. leechii, H. tokyoensis, H. lichenatus, H. nigrescens, H. sadoensis, H. abei* and *H. okiensis* are wider; those of *H. nebulosus, H. tsuensis, H. formosanus, H. naevius, H. kimurae, H. stejnegeri, H. sonani* and *H. boulengeri*[(1)] are longer; that of *H. retardatus* is shorter.

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(1) Sato [8] regarded *Pachypalaminus* as an independent genus, but it is inculuded in the genus *Hynobius* in the present paper according to the opinion by Nishino *et al.* [9].